Do Farm Management Practices Impact Pests' Natural Enemies in the Soil?

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Soil biodiversity is intricately linked to soil health, impacting many key plant processes and even soil-insect interactions. For the major apple pest plum curculio (PC), *Conotrachelus nenuphar*, soil serves as an important medium for larval development. An integrated pest management (IPM) practice for controlling PC involves the application of entomopathogenic nematodes (EPNs) underneath designated attract-and-kill trees which serve as designated spray areas to limit pesticide applications [1]. This practice involves the augmentative release of EPNs, bolstering the soil community's number of insect predators, thus allowing the next season's PC to be effectively controlled in advance.

A soil-based pest management practice is rooted in the concept of insect pest-suppressive soils, where microorganisms (such as EPNs, entomopathogenic fungi, and bacteria/protozoa) kill soil-dwelling pests [2]. As discussed above, one way farmers can ensure sufficient soil biodiversity of suppressive microorganisms is through purchasing and applying them as a biological control. However, this approach requires more research on their ability to overwinter and potential to control next year's pests, to reduce the cost of yearly applications. A more holistic approach to increase soil biodiversity involves the deintensification of agricultural practices, such as limiting traditional cultural and conventional management practices that habitually disturb the soil ecosystem [3].

To examine the impact of management practices on the biological control capacity of native soil suppressive organisms, we surveyed soils for native sources of insect mortality from two extremes: (1) older completely unmanaged apple trees and (2) traditionally managed apple trees. We hypothesized that the soil from unmanaged trees would support a more suppressive community, with higher populations of biological control agents such as EPNs, than soil from traditionally managed trees.

Materials and Methods

The assessment of native suppressive organisms took place at two fruit farms in Western Massachusetts: (1) UMass Amherst Cold Spring Orchard (CSO) located in Belchertown, MA, and (2) an organic farm located in Amherst, MA. The UMass CSO is a research orchard under traditional conventional and cultural management. Research was conducted in two different blocks (X block and Empire (E) block) both of which have established apple trees. The organic farm has some older trees within the orchard that are no longer managed. Managed was defined as trees that receive routine insecticide, fungicide, and herbicide treatments as well as fertilizers.

For each block, 4 random trees were chosen for sampling, each serving as a replicate. Underneath each replicate, five sites were randomly selected and soil was dug up from near the trunk ranging to the furthest branch. Each soil sample was dug to a depth of 8-10 cm, the greatest estimated depth at which plum curculio larvae pupate at. Once dug up, the top level of organic matter was removed an`d the 5 soil samples were thoroughly mixed into a soil sample representing the soil of the replicate. This methodology was repeated for each replicate at each block surveyed.

In the laboratory, the three types of soil samples were evenly split into sanitized containers. In each soil sample 20 wax moth larvae were placed as prey. There were 80 wax moth larvae per control and 160 wax moth larvae were monitored across the two controls.

Mortality was documented at 24-, 48-, and 72-hours post-application of control. We used wax moth larvae as a proxy for plum curculio, given that at the moment of conducting the study no PC larvae were available, and due to their documented high susceptibility to EPNs.

Results

We found significantly higher mortality of wax moth larvae in the unmanaged orchard's soil samples at 48 hours as well as at 72 hours when compared to larval mortality recorded in the two managed blocks, X and E (Fig. 1). In some of the wax moth larvae cadavers, we observed reddish coloration, suggestive of *Heterobacteriophora* EPN species.

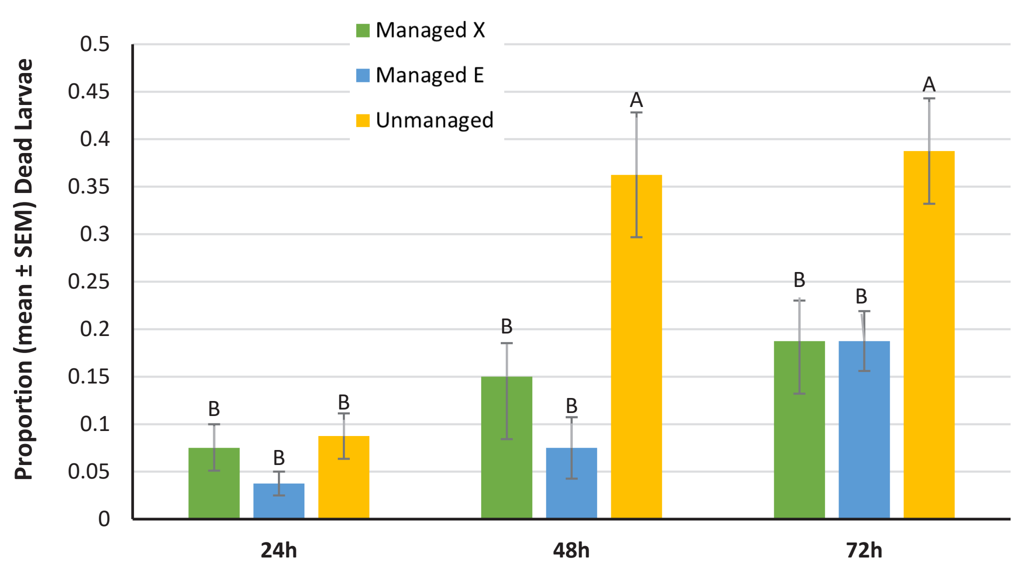

Figure 1. Comparison of Wax Moth Larval Mortality Between Managed and Unmanaged Sites in Massachusetts. We compared the proportion of wax moth mortality in water-treated samples from X-block, E-block, and P-block. Block mortality rates are shown for 24, 48, and 72 hours post-treatment. Standard errors are shown by 'whiskers'. For each time period, different letters represent statistically significant differences between groups at odds 19:1.

Conclusion

This small study confirmed our hypothesis that orchard pest management seems to influences the level to which soils can be pest-suppressive. Soil sampled from unmanaged trees exerted greater pest mortality compared to soil sampled from managed apple blocks. Future research will evaluate whether soils associated with apple trees that receive increased pest injury (thereby providing more 'food' to soil entomopathogenic organisms) can produce greater pest mortality (= more pest-suppressive soils) compared to soils sampled from apple trees that receive less injury.

Glossary

Entomopathogenic: insect-killing organisms such as nematodes and fungi.

Augmentative release: releasing additional natural enemies when native populations are too low to effectively control the pest.

Literature Cited

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2. Kassoy, J., Garofalo, E., and Piñero, J.C. 2022. Insect Pest-Suppressive Soils. *UMass Extension Fruit Team*, Fact Sheet #IPMG 002.

3. Tsiafouli, M.A., Thébault, E., Sgardelis, S.P. et. al. 2-14. Intensive agriculture reduces soil biodiversity across Europe. *Global Change Biology*, no. 21: 973-985.

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ACCEDE™ Peach Grower Trials in 2021, 2023 in New Jersey

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Win Cowgill
Professor Emeritus Rutgers University
Win Enterprises International, LLC

ACCEDE™ - A New Apple and Peach Thinner. A new PGR thinner was released by Valent in 2021 under an experimental use permit.

- Trials were conducted in California, NJ, MI, Ohio, PA, NY, MA, VA, NC, SC, and GA (Figure 1).

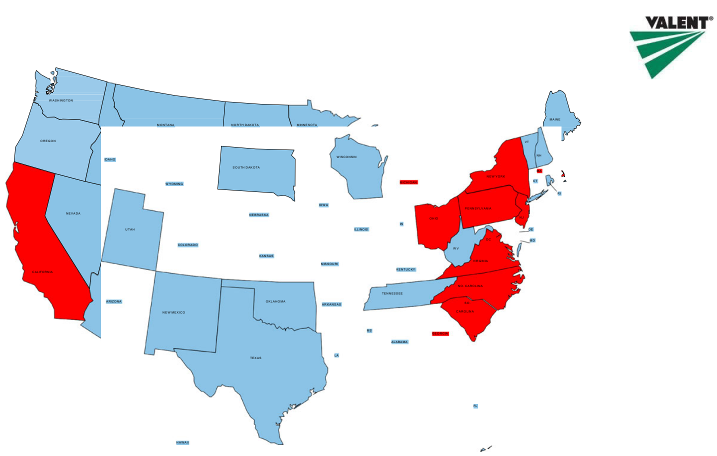

Figure 1. 2021-2022 Accede Commercial Field Trials on Peach and Nectarine.

- Over 10 grower locations in NJ in 2021, ACCEDE™ was applied by growers under the EU permit in 2021.
- The active ingredient is ACC, applied at bloom, which causes the peach to promote Ethylene which causes a % of the flowers to abscise.
- Accede is now fully labeled for use in the USA for peach and apple thinning.
- Thinning peach flowers rather than fruit allows the tree to conserve more nutrients and carbohydrates so that can support the remaining fruit better, resulting in larger fruit size.
- All ACCEDE™ treatments required additional hand thinning.

2022 Jersey ACCEDE™ Trial Overview

- In 2022 ACCEDE™ a smaller number of trials were conducted by 3 peach growers in New Jersey (two in the southern part and one in the northern part) (Many north Jersey growers and peach cold injury and did not use ACCEDE™ in 2022.
- *Accede*™ was applied with one application @ at the lower rate of 300 ppm with a spray volume of 100 GPA when peaches were 20 to 100% bloom.
- A non-ionic surfactant (NIS) added to the spray solution at 0.05% (v/v).
- Peach varieties treated in New Jersey were Andy's Candy, Carolina Red, Evelyn, Gloria, Snow Giant, White Lady, Flaming Fury including PF 8 (white), PF 8 (yellow), PF 9, PF 12, PF 13, PF 27, PF 28, PF 35, and PF 42.
- All varieties had a heavy bloom and were applied at bloom.
- Bloom treatment was compared to an untreated control.
- ***2022 NJ trials averaged a 49% reduction in fruit set (Figure 2).***
- ***2022 NJ trials averaged 32% increase in fruit weight (Figure 3).***

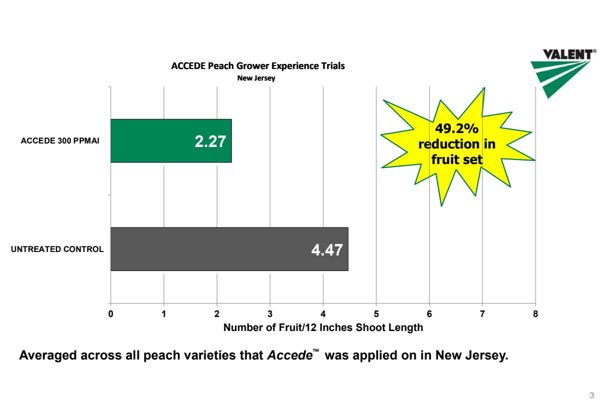

Figure 2. 2022 NJ reduction in fruit set.

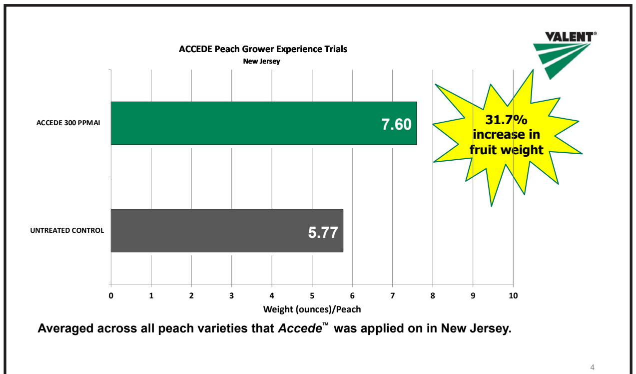

Figure 3. 2022 NJ Increase in fruit weight.

USA Summary of Fruit Set reduction by peach varieties trialed across the US. There are differences by variety (Figure 4).

- Thinning results varied from a few percent to 80 percent but averaged 38%.
- Reduction in hand thinning time 44%.
- Increase in fruit size 8%.

2023 NEW Jersey ACCEDE™ trials

- Multiple grower trials are in place across north and southern NJ.
- Two replicated trials, one each in Hunterdon and Morris County have been established.
- Bloom in North Jersey was approximately 14 days earlier than past years.
- Treatments were applied at full bloom/beginning PF on April 14 (Figure 5).
- Evaluation 10 days after treatment with **ACCEDE™** treatment effects clear, fruit aborting on treated trees, and healthy on UTC trees (Figures 6, 7, 8; Photo Credits, Win Cowgill).

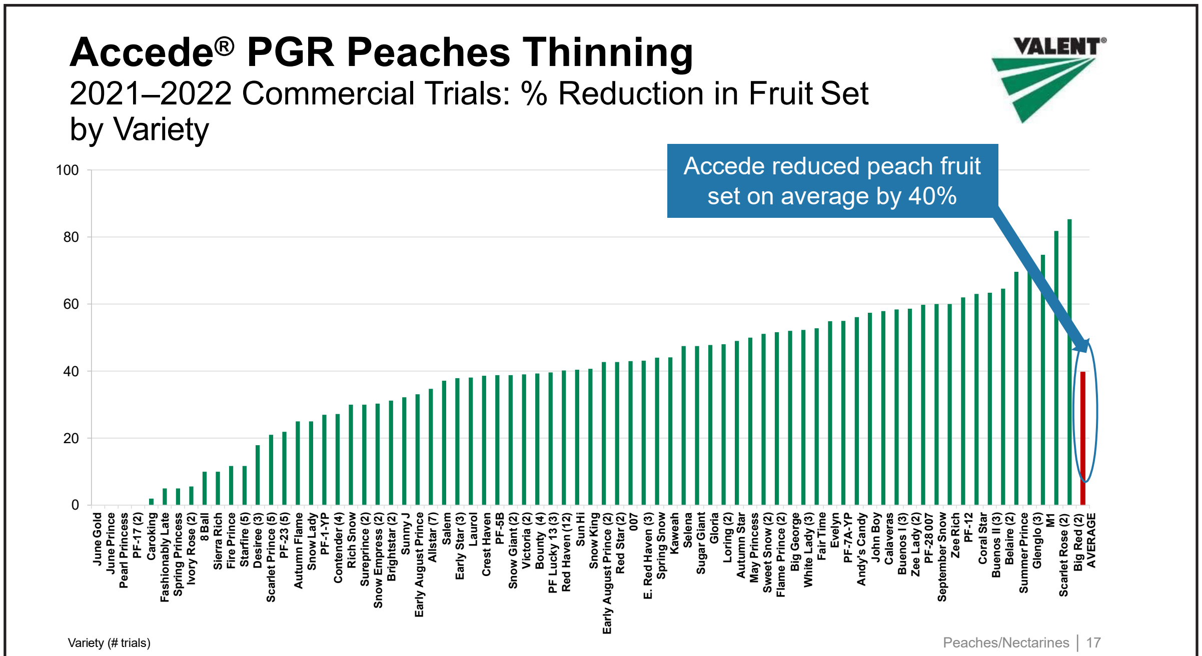

Figure 4. Summary of fruit set reduction by peach varieties trialed across the US.

Figure 5. Morris County, NJ - Full Bloom at treatment with Accede.

Figure 6. Hunterdon County, NJ - Peach fruit 11 days after treatment with Accede-brown sepals, % flowers/fruit aborting.

Figure 7. Hunterdon County, NJ - Peach fruit 11 days after treatment with Accede-brown sepals, % flowers/fruit aborting.

Figure 8. Hunterdon County, NJ - Peach fruit, untreated control flowers 11 days after Accede-treatment date- most fruit growing, sepals look healthy, have color.

Wintergreen Oil Improves the Effectiveness of the Odor-Baited Trap Tree Approach for Plum Curculio Monitoring and Attract-and-Kill

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Field studies conducted by UMass researchers and collaborators for the last 20 years revealed that benzaldehyde (BEN) in combination with grandisoic acid (GA) acted in synergy. This discovery led to the development of a monitoring strategy termed the odor-baited trap tree approach. By baiting the perimeter row trees with the synergistic lure and monitoring those trap trees, improved IPM decisions for the entire orchard can be made. While the effectiveness of the trap-tree approach has been validated multiple times throughout New England, the high cost of the lure (>$20 per trap tree) and degradation of commercial BEN lures by UV light and heat have contributed to limited grower adoption. Thus, the identification of an alternative plant volatile to replace the BEN lure is needed.

During the spring and summer of 2020 and 2021 we conducted field-scale research aimed at testing the attractiveness of wintergreen oil to adult PCs in terms of both trap captures using black pyramid traps and fruit injury levels using odor-baited trap trees. The active ingredient of wintergreen oil is methyl salicylate (MES), a volatile compound that is emitted by many plant species. MES is cheaper than BEN, and more stable, chemically speaking. Therefore, we were very interested in determining whether MES could replace BEN. The 2020 and 2021 studies yielded positive results. Here, we are presenting the research results of 2022 filed evaluations of MES, either alone or in combination with GA to PC, when compared against that of the binary combination of BEN + GA. We also sought to determine whether the level of injury received by odor-baited trap trees extend to neighboring trees potentially resulting in spill-over effects.

Materials and Methods

The field experiment was conducted at five different orchards in Massachusetts (University of Massachusetts Cold Spring Orchard (Belchertown, MA), Breezeland Orchard (Warren, MA), Red Apple Farm (Phillipston, MA), Clarkdale Fruit Farm (Deerfield, MA), Sholan Farms (Leominster, MA) and one in New Hampshire (Poverty Lane Orchards, Lebanon, NH).

This study involved lures deployed within the canopies of perimeter-row trees. The treatments were: (1) 1 methyl salicylate (MES dispenser, (2) 1 MES dispenser + 1 GA dispenser, (3) 4 BEN dispensers + 1 GA dispenser, and (4) unbaited. The treatment involving 4 BEN dispensers + 1 GA dispenser is the standard lure concentration based on previous studies. Each treatment was replicated 27 times throughout the six participant orchards. The number of replications differed among the orchards based on the availability of blocks large enough to contain the treatments. Perimeter-row trap trees were baited with the above-mentioned lure combinations during early bloom (6-10 May). Each treatment dispenser was placed inside an inverted red plastic cup to provide additional protection from rainfall and degradation by UV light and suspended evenly from branches at head height within the tree canopy. MES, BEN, and GA dispensers were replaced once every four weeks.

Fruit injury assessments were conducted to evaluate the attractiveness of the treatments to PCs. The assessments were conducted once between 28 May and 8 June, 2022. The total number of fruits with PC oviposition scars based on a random sample of 30 fruits per treatment trap tree was recorded. In all, 3,240 fruits were inspected for PC injury. To quantify any potential spillover effect to the trees immediately adjacent to the treatment trap trees, a sample of 30 fruits per tree was inspected for PC oviposition scars from two adjacent trees (right and left) to the odor-baited trap trees and the control unbaited trap trees. In addition, 30 fruits from two trees behind the odor-baited trap (i.e., located in rows 2 and 3) trees were inspected, as well as unbaited trap trees (Figure 1).

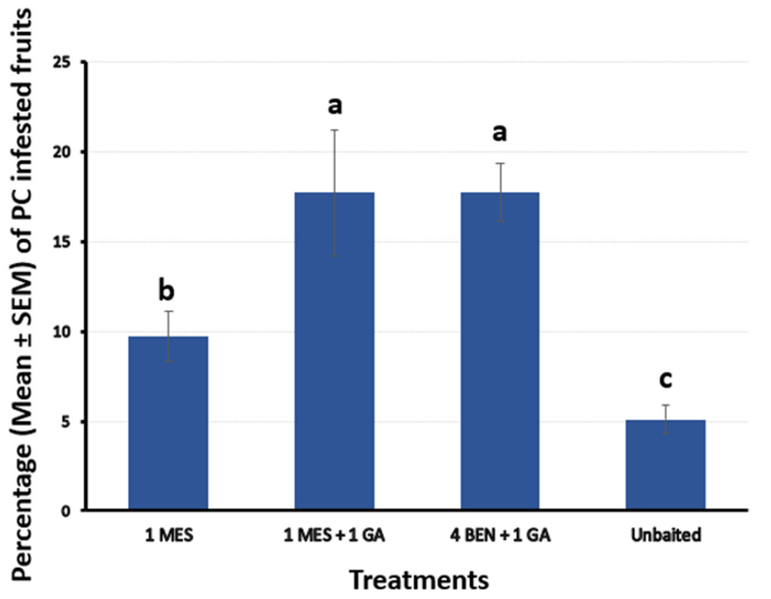

Figure 2. Percentage (mean ± SEM) of plum curculio-infested fruits on trap trees baited with three olfactory treatments versus unbaited trees. MES= Methyl salicylate; GA= grandisoic acid (PC pheromone), BEN= Benzaldehyde. Bars superscribed by the same letter are not significantly different at odds 1:19.

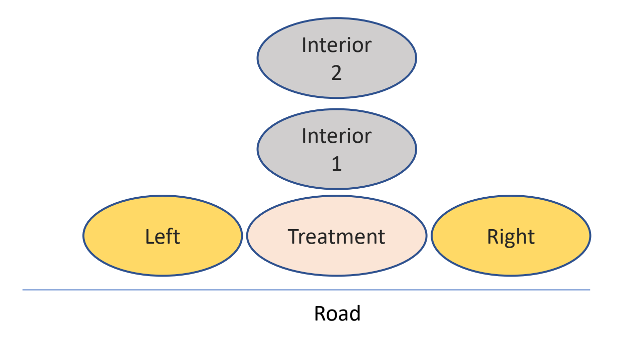

Figure 1. Diagram showing the fruit-sampling scheme in 2022. Treatment trees represent odor-baited trees or unbaited (control) trees. Adjacent left and right unbaited are referred to as neighboring trees (results present the average of both trees). Interior trees: two unbaited trees located behind the treatment tree (i.e., located in rows 2 and 3).

Results

Attractiveness of methyl salicylate to PC. Across all orchards, the average level of PC injured fruit on baited trap trees was greatest for 1 MES dispenser + 1 GA dispenser and with 4 BEN dispensers + 1 GA dispenser, both showing identical levels of PC injury (17.7%). Both types of odor-baited trees received significantly more injury than unbaited trap trees (5%) (Figure 2). MES tested singly (= 1 MES dispenser) showed an intermediate PC injury-aggregation effect with an average level of fruit injury of 9.7% (Figure 2).

Assessment of spillover effect onto adjacent trees. Overall, results showed no spillover effects. The average level of fruit being injured by PC on trap trees baited with 1 MES dispenser alone (9.8%) was significantly greater than that recorded on the neighboring trees (left and right trees combined) (5.5%), the first interior trees (4.3%), and the second interior trees (2.9%) ($P < 0.05$) (Figure 3A). There were non-significant differences in the level of PC injured fruits among neighbor trees, the first interior trees, and the second interior trees (Figure 3A).

The average level of fruit being injured by PC on trap trees baited with 1 MES dispenser + 1GA dispenser (17.7%) was significantly greater than that recorded on the neighboring trees (6.9%), the first interior trees (5%), and the second interior trees (3%) (Figure 3B). The average level of PC injured fruit on trap trees baited with 4 BEN dispensers + 1 GA dispenser (17.7%) was significantly greater than that recorded on the neighboring trees (8%), the first interior trees (5%), and the second interior trees (3%) (Figure 3C). Moreover, the average level of PC injured fruit on neighboring trees was not significantly greater than that recorded on the first interior trees but was significantly greater than those recorded on the second interior trees (Figure 3C). It was also observed that there were non-significant differences in the average levels of PC injury to fruit between the first interior trees and the second interior trees (Figure 3C).

The average level of PC injured fruits on unbaited trap trees (5.1%) was not significantly different from that recorded on the neighboring trees (4.7%), and the first interior trees (3.7%) but was significantly greater than the level observed on the second interior trees (1.6%) (Figure 3D).

In terms of costs of lures, the 1 MES dispenser + 1 GA dispenser combination is less expensive than the standard lure consisting of 4 BEN dispensers + 1 GA lure per trap tree. The cost of 1 MES dispenser is ca. $3, and 1 GA dispenser is ca. $8. Therefore, the total cost for 1 MES dispenser + 1 GA dispenser would be half of the cost of 4 BEN dispensers + 1 GA dispenser which is greater than $20. In addition to its relatively high cost, BEN lure is unstable, and it converts to benzoic acid under high UV light and heat (Leskey et al. 2005). In contrast, MES lure was found to continue to emit odor two months after initial deployment. The PC season typically lasts 6 weeks, therefore a single MES dispenser is expected to last the entire period of PC activity.

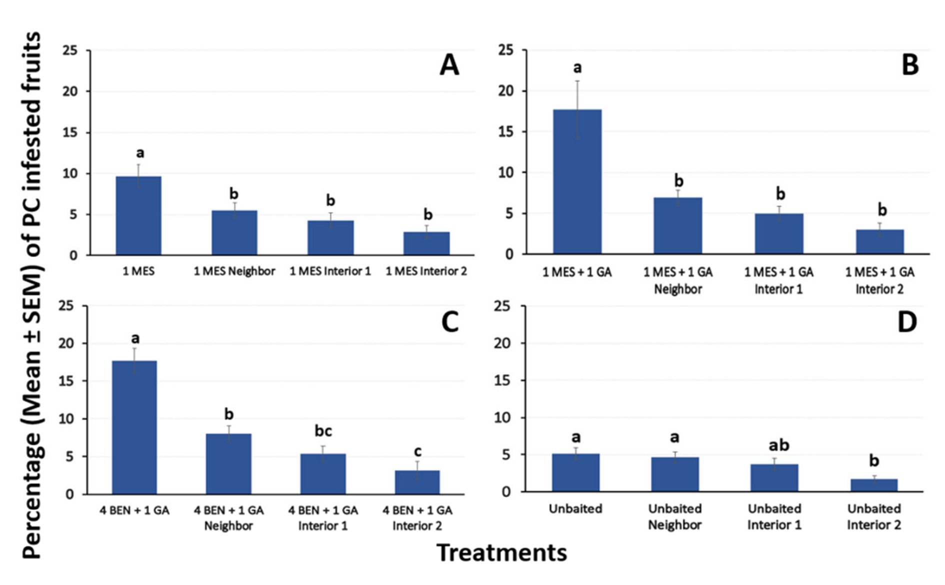

Figure 3. Mean percent (± SEM) injury by PC to fruit sampled from treatment trees, neighboring trees, and interior-row trees: (A) trap tree baited with 1 MES, (B) trap tree baited with 1 MES + 1 GA, (C) trap tree baited with 4 BEN+ 1 GA, and (D) unbaited trap tree. For a description of the fruit-sampling scheme, see figure 1. For each chart, bars superscribed by the same letter are not significantly different at odds 1:19.

Conclusions

Our collective findings showed that 1 MES + 1 GA is as attractive to PCs as the standard synergistic lure composed of 4 BEN + GA. These findings could increase the likelihood of adoption of the trap-tree approach for monitoring and also for reduced insecticide sprays against PC in New England apple orchards.

Acknowledgments

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